

C-2821

In the Claims:

1. (Withdrawn) A fuel cell system including a cell stack comprising a plurality of adjacent fuel cells, each cell comprising a) an anode plate means, b) a cathode plate means, and c) an electrolyte layer sandwiched between said anode and cathode plate means;

said stack also including a hydrophobic barrier layer having a first side and second side and being sandwiched between and in contact with said anode plate means of one of said fuel cells and said cathode plate means of another of said fuel cells, said barrier layer being porous to water vapor while having a water intrusion pressure sufficiently high to prevent liquid water from passing therethrough under expected fuel cell system operating conditions;

wherein one of either said anode or cathode plate means defines, with said first side of said barrier layer, channels for carrying liquid water adjacent said first side of said barrier layer and out of said fuel cell;

and, wherein the other one of said anode or cathode plate means defines, with said second side of said barrier layer, channels for receiving steam from said liquid water channels and for carrying that steam out of said fuel cells;

said fuel cell system also including a) means connected to said liquid water channels for feeding a stream of liquid water into said liquid water channels during fuel cell operation; b) means for sensing the temperature at which the fuel cells are operating; c) temperature control means including means i) for reducing the pressure within said steam channels to below the vapor pressure of water within said water channels to boil the water to produce steam and evaporatively cool the cells, and ii) for adjusting said steam channel pressure in response to said temperature sensing means to control the amount of evaporative cooling and maintain a desired fuel cell operating temperature range.

2. (Withdrawn) The fuel cell system according to claim 1, wherein said water

C-2821

channels are defined between said anode plate means and said barrier layer and said steam channels are defined between said cathode plate means and said barrier layer.

3. (Withdrawn) The fuel cell according to claim 1, wherein said electrolyte layer is a PEM.

4. (Withdrawn) The fuel cell system according to claim 3, wherein said means (i) for reducing pressure includes a vacuum pump in communication with said steam channels and said means (ii) for adjusting said steam channel pressure is a radiator for removing heat from the steam after it leaves said steam channels.

5. (Withdrawn) The fuel cell system according to claim 3, wherein said anode plate is a porous, hydrophilic water transport plate and said cathode plate is a porous, hydrophilic water transport plate.

6. (Withdrawn) The fuel cell system according to claim 4, wherein said anode plate is a porous, hydrophilic water transport plate and said cathode plate is a porous, hydrophilic water transport plate.

7. (Withdrawn) The fuel cell system according to claim 3, wherein at least one of said anode plate and cathode plate is a non-porous separator plate.

8. (Withdrawn) The fuel cell system according to claim 3, wherein both said anode plate and said cathode plate are non-porous separator plates.

9. (Withdrawn) The fuel cell system according to claim 4, wherein at least

C-2821

one of said anode plate and cathode plate is a non-porous separator plate.

10. (Withdrawn) The fuel cell system according to claim 4, wherein both said anode plate and said cathode plate are non-porous separator plates.

11. (Withdrawn) The fuel cell system according to claim 6, including a water accumulator for receiving condensed water from said radiator, wherein said water feeding means includes water pump means for pumping water from said accumulator into and through said water channels.

12. (Previously Presented) In a stack of fuel cells, wherein adjacent cells are separated by a porous, hydrophobic barrier layer having a water intrusion pressure that prevents liquid water from crossing between cells through the barrier layer under normal operating conditions, the cell on one side of the barrier layer defining a flow channel for liquid water adjacent that one side of the barrier layer, the cell on the other side of the barrier layer defining a flow channel for steam adjacent that other side of the barrier layer, said water and steam flow channels being in vapor communication with each other through the barrier layer, the process of cooling the fuel cells by evaporative cooling during fuel cell operation comprising the steps of:

flowing liquid water into and through the water flow channel and out of the fuel cell, the water being heated within the water channel by heat produced by the fuel cell;

causing the liquid water to boil as it flows through the water channel by reducing the pressure in the steam channel below the vapor pressure of the flowing liquid water to convert at least some of the water to steam that passes through the barrier layer into the steam channel, wherein the pressure in the steam channel is increased or decreased during cell operation in response to the operating temperature of the cell to increase or decrease the operating temperature of the cell to achieve a desired cell

C-2821

operating temperature; and

condensing the steam outside the fuel cell and recirculating a portion of the condensed steam back to the flowing liquid water, wherein the steam originated as the flowing liquid water converted into steam and passed through the barrier layer into the steam channel.

13. (Original) The cooling process according to claim 12, wherein the step of reducing the pressure in the steam channel includes drawing a vacuum in the steam channel, and the step of increasing or decreasing the pressure in the steam channel includes passing the steam through a radiator after it leaves the cell and controlling the amount of heat removed from the steam within the radiator.

14. (Original) The cooling process according to claim 13, wherein steam is condensed to water within the radiator and at least a portion of the condensate is made available for recirculation through said water channels.

15. (Original) The cooling process according to claim 13, wherein each fuel cell includes a PEM and operates on reactant gasses that are at substantially atmospheric pressure, and the pressure in the steam channels is controlled to maintain the cell operating temperature between 150°F and 180°F.

16. (Original) A method for evaporatively cooling a plurality of adjacent fuel cells, wherein each cell comprises an electrolyte layer sandwiched between a porous anode water transport plate and a porous cathode water transport plate, the anode plate of one cell extending from the electrolyte layer of the cell to one side of a porous hydrophobic, electrically conductive barrier layer separating the two adjacent cells, and the cathode plate of the adjacent cell

C-2821

extending from the electrolyte layer of said adjacent cell to the other side of said barrier layer, the steps of:

a) flowing liquid water adjacent one side of the barrier layer through first channels formed between one of the cell water transport plates and the barrier layer;

b) drawing a vacuum in second channels formed between the transport plate of the adjacent cell and the other side of the barrier layer to reduce the pressure in the second channels to below the vapor pressure of the water in the first channels to cause the liquid water to boil and produce steam that passes through the barrier layer into the second channels;

c) removing the steam from the second channels; and,

d) controlling the amount of evaporative cooling by controlling the steam pressure in the second channels.

17. (Original) The method according to claim 16, wherein the electrolyte layer is a PEM.

18. (Original) The method according to claim 16, wherein the step (d) of controlling the amount of evaporative cooling includes passing the steam from the second channels through a radiator that includes a fan, and controlling the speed of the fan to control the steam pressure in the second channels.

19. (Original) The method according to claim 16, wherein in step (d) the operating temperature of the cell is continuously determined and the amount of evaporative cooling is regulated by adjusting the steam pressure within the steam channels in response to the operating temperature to maintain or change the operating temperature as desired.

C-2821

20. (Original) The method according to claim 19, wherein the electrolyte layer is a PEM.

21. (Original) The method according to claim 18, wherein the step of passing the steam through a radiator includes condensing steam to liquid water, wherein some of that condensed liquid water is directed into a water accumulator and recirculated through the first channels as needed.